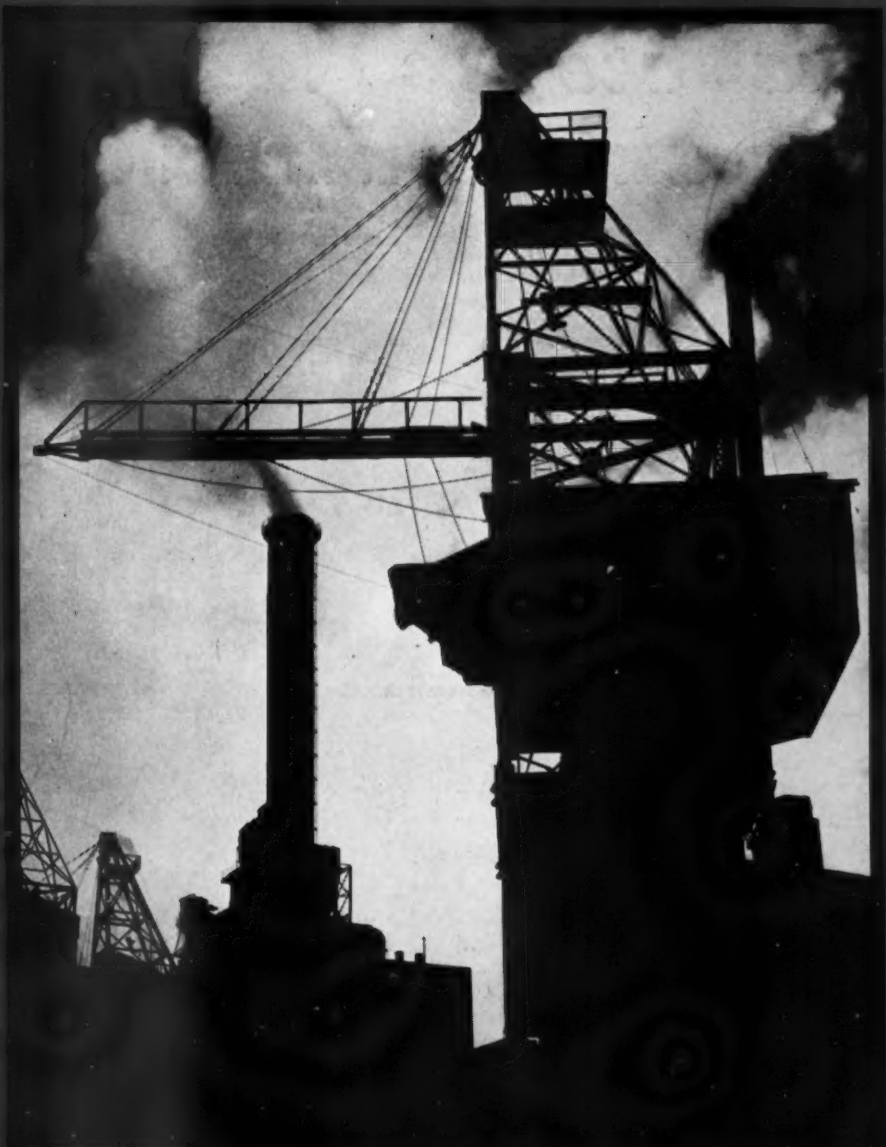
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 11, No. 7 JANUARY, 1940 25c a copy



Robert Photo Features

A Survey of the Present Fuel Oil Situation

The Electric Light and Power Industry in 1939

Further Power Plant Standardization in Germany

Central Station Steam Generating Units of 1939

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME ELEVEN NUMBER SEVEN

CONTENTS

FOR JANUARY 1940

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

H. STUART ACHESON, *Advertising Manager*

ALFRED D. BLAKE, *Editor*

THOMAS E. HANLEY, *Circulation Manager*

Combustion is published monthly by Combustion Publishing Company, Inc., a subsidiary of Combustion Engineering Company, Inc., 200 Madison Avenue, New York. Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer. It is sent gratis to consulting and designing engineers and those in charge of steam plants from 500 rated boiler horsepower up. To others the subscription rate, including postage, is $2 in the United States, $2.50 in Canada and Great Britain and $3 in other countries. Single copies: 25 cents. Printed in U. S. A. Publication office, 200 Madison Avenue, New York. Issued the middle of the month of publication.

Member, Controlled Circulation Audit, Inc.

CCA

PARTIAL LIST OF ORDERS RECEIVED

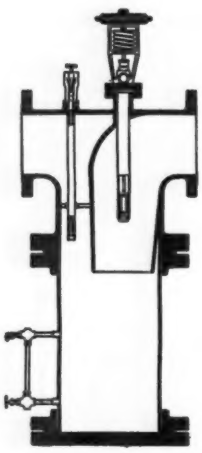
FOR THE COPES FLOWMATIC REGULATOR

		BOILER DATA			
USER AND LOCATION	DATE	NO.	MAKE	WSP LB.	MAX.EVAP. LB./HR.
Canadian Chemical Plant	1939	1	F-W	80	20,000
Canadian Mining Plant	1939	1	B & W	175	66,000
Canadian Steel Mill	1937	1	Freyn	130	25,000
and.	1939	1	Freyn	130	25,000
Colorado Sugar Mill	1939	1	C-E	155	115,000
Connecticut Industrial Plant	1937	2	Riley	700	90,000
Connecticut Industrial Plant	1939	1	E. M.	200	70,000
Connecticut Utility Plant	1938	1	B & W	675	125,000
and.	1939	1	B & W	675	125,000
Georgia Textile Mill	1939	1	B & W	425	80,000
Illinois Industrial Plant	1937	2	Riley	700	90,000
Illinois Mining Plant	1938	1	E. M.	120	60,000
Illinois Refinery Plant	1939	1	Riley	650	120,000
Illinois Utility Plant	1939	2	B & W	670	350,000
Iowa Institutional Plant	1939	1	B & W	185	52,000
Iowa Utility Plant	1939	1	C-E	725	100,000
Kansas Utility Plant	1938	2	F-W	650	70,000
Kansas Utility Plant	1939	1	B & W	420	185,000
Maryland Textile Mill	1937	2	Riley	450	200,000
Massachusetts Industrial	1939	1	B & W	600	65,000
Massachusetts Industrial	1939	2	Riley	650	50,000
Massachusetts Utility Plant	1939	4	B & W	1300	300,000
Michigan Chemical Plant	1938	1	F-W	1325	300,000
Michigan Paper Mill	1937	1	Baden.	550	110,000
Michigan Paper Mill	1939	1	C-E	650	48,000
Michigan Rubber Mill	1937	3	Lasker	425	30,000
Michigan Utility Plant	1937	1	B & W	850	400,000
Michigan Utility Plant	1938	1	F-W	875	400,000
and.	1939	1	F-W	875	400,000
Michigan Utility Plant	1939	2	F-W	875	400,000
Missouri Industrial Plants	1938	1	Erie	450	90,000
Missouri Utility Plant	1938	1	B & W	225	120,000
and.	1938	2	W & W	180	110,000

		BOILER DATA			
USER AND LOCATION	DATE	NO.	MAKE	WSP LB.	MAX.EVAP. LB./HR.
Nebraska Utility Plant	1938	3	B & W	400	140,000
Nebraska Utility Plant	1938	2	C-E	475	200,000
New Jersey Industrial Plant	1938	2	C-E	450	65,000
New Jersey Industrial Plant	1939	2	B & W	155	60,000
New Jersey Paper Mill	1939	1	B & W	400	115,000
New York Brewery Plant	1938	3	C-E	410	75,000
New York Housing Project	1939	4	F-W	500	135,000
New York Industrial Plant	1938	1	Baden.	650	100,000
New York Salt Plant	1939	1	Riley	200	150,000
North Carolina Paper Mill	1938	2	C-E	440	35,000
Ohio Leather Plant	1939	1	Erie	110	75,000
Ohio Steel Mill	1938	2	B & W	415	330,000
Ohio Textile Mill	1937	1	Vogt	500	85,000
Pennsylvania Industrial	1938	1	Vogt	450	100,000
Pennsylvania Paper Mill	1938	1	Sprgfld	600	100,000
and.	1939	1	Sprgfld	600	100,000
Pennsylvania Paper Mill	1939	1	B & W	610	125,000
Pennsylvania Steel Mill	1938	1	B & W	400	85,000
and.	1939	1	B & W	400	85,000
Pennsylvania Steel Mill	1938	3	Erie	250	150,000
Pennsylvania Steel Mill	1939	1	B & W	165	50,000
Pennsylvania Steel Mill	1939	1	F-W	660	150,000
Pennsylvania Utility Plant	1937	1	B & W	675	200,000
Pennsylvania Utility Plant	1937	1	F-W	875	400,000
Texas Chemical Plant	1937	1	B & W	400	200,000
Texas Refinery Plant	1937	1	Riley	600	350,000
Texas Utility Plant	1937	1	Riley	450	160,000
Virginia Textile Mill	1939	2	B & W	600	75,000
Virginia Utility Plant	1939	1	C-E	225	80,000
Washington Ship Yard	1939	1	B & W	450	125,000
Washington Utility Plant	1939	1	C-E	690	550,000
West Virginia Mining Plant	1939	3	C-E	167	45,000

Name of any user listed above will be furnished on request

They're getting *more* for their money with COPES Flowmatic



...and with COPES Reducing and Desuperheating Stations

You get more for your money in COPES Pressure Reducing and Desuperheating Stations. You get the long life and trouble-free fully-automatic service built into all COPES equipment, plus the uncanny accuracy of control made possible by exclusive design features. Reducing Valves are better balanced, more accurately calibrated. Desuperheaters more accurately proportion cooling water to steam on all flows from maximum to minimum. Write us about your operating requirements.

Users of the simplified COPES Flowmatic Regulator get more for their money because of safer, more efficient, more dependable performance. Safer—because of closer boiler water level control on their most rapidly swinging loads. More efficient—because feed input is more accurately geared to steam output. More dependable—because only routine attention is needed to assure trouble-free service, and because the COPES is independent of all other control and metering systems, not subject to their outages. These are good reasons why the number of satisfied users is growing so rapidly. If you want more for the money you invest in feed water regulation, specify the fully automatic, two-element COPES Flowmatic. Write for Bulletin 409-B.

NORTHERN EQUIPMENT CO., 106 GROVE DRIVE, ERIE, PA.

Feed Water Regulators, Pump Governors, Differential Valves
Liquid Level Controls, Reducing Valves and Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY AND ITALY
REPRESENTATIVES EVERYWHERE

★ GET CLOSER LEVEL CONTROL WITH THE COPES FLOWMATIC ★ REGULATOR

EDITORIAL

Electrical Production Resumes Its Stride

It has become customary to measure present activities with those of 1929 as a yardstick, regardless of the fact that much of the prosperity of that year now appears to have been stimulated artificially rather than by normal growth. Despite this, the 1939 production of electricity exceeded that of 1929 by 22 per cent, industrial power sales were 25 per cent greater and the domestic consumption increased from 500 to 900 kwhr per consumer. What the totals might have been without the stagnation of depression years is impossible to estimate for it is improbable that the rate of increase of the '20's would have continued in a straight line.

Until returns from the 1940 census of population, business and industry become available during the second half of this year, it will be impossible to correlate growth during the last ten years with the increase in electrical demand. However, the 1939 figures are most encouraging and indicative of what may be expected during the next few years, barring unforeseen adverse conditions.

Embrittlement Research and the Sulphate-Alkalinity Ratio

Some years ago numerous failures of riveted drums, due to cracking of the metal adjacent to rivet holes, first drew attention to the existence of so-called caustic embrittlement, or intercrystalline cracking. Much controversy ensued as to the contributing causes, which finally were credited to a combination of excessive local stress in the metal and the building up of high concentrations of sodium hydroxide and silica at these locations.

Subsequent operating experience indicated that if certain ratios of sodium sulphate to total sodium hydroxide and sodium-carbonate alkalinity were maintained in the boiler water that caustic embrittlement could be avoided. These recommended ratios were therefore incorporated in the A.S.M.E. Code for the Care of Power Boilers. However, this was in the days of riveted drums and relatively low pressures.

Since then, caustic embrittlement has been the subject of extensive laboratory research, as well as systematic investigation by the Joint Committee on Boiler Feedwater Studies. While much headway has been made, as shown by progress reports from year to year, the perfect inhibitor has not yet been found, and certain contradictions have developed in the research. Meanwhile, however, boiler practice has advanced, through improved design, careful workmanship, welded-drum construction for high and moderate pressures, and stress-relieving of the metal, to the point that opportunities for embrittlement in such modern boilers have become practically nil, except perhaps at tube ends.

Moreover, operation at high pressures and high ratings makes it difficult to carry the boiler-water concentrations resulting from maintenance of the A.S.M.E. ratio; as a result of which many operators of high-pressure boilers are not employing it.

A recent extensive field survey by the Committee, of boilers designed to operate at or above 400 lb pressure, indicated that with welded or forged drums, or riveted drums that have been properly and exclusively caulked internally, no embrittlement may be expected, although some failures were reported with externally caulked seams.

While some instances of failures have been reported with riveted drums where the A.S.M.E. ratio was employed, the possibility of it not having been maintained consistently and continuously throughout the life of the boilers has precluded definite deductions.

With research still in a state of flux, with field data concerning high-pressure boilers indicative rather than conclusive, and the field under 400 lb still unsurveyed, one can appreciate the reluctance of the Committee to take a definite stand as to applications of the A.S.M.E. ratio. Therefore, it is understood to be prepared, at this time, to retain the sulphate-alkalinity recommendations as applying to the lower pressure range and merely to cite the results of its survey of boilers of 400 lb and over, with forged, welded and riveted drums having exclusively internally caulked seams, for the guidance of operators of such boilers.

The subject will be brought up for further discussion at the A.S.M.E. Meeting in Worcester, Mass., next May, at which time it is expected that details will be given of an embrittlement detector that is now being tried out in several plants under actual operating conditions, as well as under exhaustive laboratory tests.

Hydro Power Proves Inadequate

A fact long appreciated by engineers, but generally ignored by proponents of widespread water-power development, is the insufficiency of most hydro power to meet all-year demands without steam plant reserve. This was strikingly illustrated during the last four months of 1939 when a deficiency in rainfall brought about a shortage of water in many localities with the result that the amount of hydro power generated fell some twelve to fifteen per cent below that for the same period of 1938. In so far as private power systems were concerned this deficiency was readily supplied by increased load on the steam plants, and it is understood that TVA found certain steam plants of the private system taken over most convenient. In fact, according to press reports, it is rumored that TVA is seriously considering requesting appropriations to construct additional steam plant reserve to back up its hydro system.

A Survey of the Present Fuel Oil Situation

By EDWARD JAMIESON
Washington, D. C.

In view of the rise in fuel oil prices and speculation as to the effect of the war on demand and future prices, all of which are pertinent to decisions regarding fuel burning for new boiler installations, Mr. Jamieson was given the assignment of collecting data, interviewing leaders in the oil industry and governmental regulatory authorities and analyzing testimony before congressional committees, in order to present a broad survey of the present fuel oil situation. Moreover, his personal qualifications include eleven years experience in watching and covering oil legislation at Washington. Briefly, his conclusions are that recent price advances were due almost entirely to depleted stocks caused by a sudden increased domestic demand, accentuated by a general shutdown of oil production in several states last August following a cut in posted crude prices; that the potential supply is adequate for many years to come; that exports have not been excessive; and that the recent reduction in duty on oil imported from Venezuela will serve to stabilize prices as will also the fear of further regulatory action by Congress.

CRUDE petroleum and its chief products, gasoline and fuel oil, have been taken for granted so long by the average American who can buy all he wants at reasonable prices that it took a major war in Europe to make him realize the value and importance of this irreplaceable natural resource.

Today, with the British, French, Germans and people of other warring nations forced to jack up their automobiles and go back to coal for fuel because of the limited amounts of petroleum which those countries can secure, most of which must be used for military purposes, the United States is beginning to take stock of what is undoubtedly its most valuable mineral product.

For the present, officials of the Federal Government and of the major oil-producing states, as well as leading oil men and geologists, declare that the United States has nothing to fear. But, they add, this does not mean that every precaution should not be taken to conserve the American supply of petroleum and insure its utilization and production with an absolute minimum of waste.

As a result, the petroleum reserves of the United States and the American oil industry, which produces the crude oil and refines it into hundreds of essential products, is undergoing one of the most thorough studies in their nearly eighty years of existence. Congress, federal departments, state agencies, the oil industry itself and officers of the army and navy have joined in a review of the American petroleum situation from which definite results may be anticipated within the next several years. Many of these inquiries are not new, but merely continuations of the studies which have made technological development in the American oil industry over the past two decades surpass anything of its kind in history.

It is too early to forecast with any certainty what will be the net result of these studies. From the investigations under way, however, several very important conclusions, which appear uncontradicted, can be drawn. In brief, they are:

1. There is a definite limit to the petroleum reserves within the United States, but there is absolutely no danger of their exhaustion or serious curtailment of production for many years to come.
2. Proration, or controlled production of crude oil, has been accepted by the industry and when thoroughly applied throughout the nation will more than double the eventual recovery of oil from underground. Whether the states, now the regulatory agency, or the Federal Government should control production, however, is an issue now pending before Congress.
3. The trend of prices for fuel oil, gasoline and other major products of crude petroleum, should be downward rather than upward during the next decade or more, because refining methods are improving steadily and distribution costs are declining.
4. The war, unless the United States becomes involved, will not affect the supply of petroleum in the United States or further increase prices of petroleum products to a material extent.
5. Long before the supply of crude petroleum in the United States nears a point of exhaustion, processes for extracting gasoline, fuel oil and other petroleum products from coal and oil bearing shales, of which there are tremendous quantities within this country at very cheap costs, will have been developed.
6. Large American oil companies, taking no chances, are financing more and more the development of oil production in South and Central America, with this country having first call on these supplies. While substantial bans on importation of these oils are now in effect, prospects are that larger quantities of the oil from these

countries will be permitted to be brought into this country in years to come.

There are many other important questions affecting the American oil problem which remain controversial, but, by and large, they affect the industry itself primarily and not the consumer. Some of these questions will be settled within the next year or two. Others will probably continue indefinitely, as they have within all other major industries of this country.

The size of the American oil reserves, concededly larger than all of the known reserves in the rest of the world together, remains a question. During recent hearings by a sub-committee of the House Interstate Commerce Committee, authorized to study the oil industry, and by the Temporary National Economic Committee, this question was asked many times. It was the consensus of witnesses appearing before the two committees that present known reserves within the United States hold between seventeen and eighteen billion barrels of oil. Since the production of crude oil today is in excess of three million barrels a day, this is not a large reserve. Representatives of the U. S. Bureau of Mines, the U. S. Geological Survey and the oil industry, however, told the two committees that the reserves in the United States known today undoubtedly represent only a fraction of the total amount of oil underlying this nation.

Improved methods of drilling, which permit wells to be sent farther into the ground today than was even dreamed of ten years ago, and more accurate prospecting methods, mean that many new oil fields with large production will be discovered in the United States before the total supply of oil in this country is exhausted.

During a recent hearing before the House Committee, representatives of the Bureau of Mines and of the Geological Survey, frankly declared that they did not know the amount of known reserves of petroleum in the United States and declined to hazard a guess on the prospective reserves.

"I can not give you any figure in terms of years as to how long our petroleum supply will last, because we do not know," Hugh D. Miser, geologist in charge of the Geological Survey, said. A witness before the TNEC told of a new geo-chemical method of oil discovery now being perfected which may uncover oil fields in sections of the United States which up to the present time have not even been prospected.

Determination of Reserves Likely

Disclosure during the hearings that the Federal Goverment has no means of attempting to ascertain the amount of known petroleum reserves within the nation's borders may result in the appropriation of funds to establish a division of the Bureau of Mines to do this work. Committee members expressed amazement that federal agencies are forced to rely on figures supplied by the American Petroleum Institute and other private sources, and hinted that they would recommend legislation which would give the government its own official estimates.

Had no new oil fields been discovered in the United States during the past decade, the recoverable reserves of oil would have been more than doubled through the general adoption by the states of production control, utilizing the ultimate lifting power of the natural gas in the oil reservoirs. Colonel Ernest O. Thompson of the Texas Railroad Commission told the TNEC that through scientific control of production in the gigantic East Texas Oil field, the ultimate recovery of oil from the field has been increased from an original estimate of two billion barrels to five billion or more barrels.

Officials estimate that in some of the flush fields of Oklahoma, produced under the wasteful methods in the early twenties, not more than forty per cent of the oil within the pools was recovered. Billions of cubic feet of gas, which might have been used to recover this oil, was blown into the air and gone forever.

Fortunately, much of the oil in these pools which up to a year or two ago was believed beyond recovery, may soon be brought to the surface through a re-pressuring process utilizing water forced into the oil pools under extremely high pressure. Plans are already under way to put this process into operation in several of the largest fields now virtually abandoned. The process, however, is too expensive to permit its use in smaller pools and fields.

Federal versus State Regulation

Despite present wide adoption of proration, all is not serene; for a vigorous battle is now on between federal authorities and state regulatory agencies over this question. Boiled down, the fight involves whether the state or federal governments should control the production of petroleum.

It started during the days of the NRA, when Secretary of the Interior Harold L. Ickes was Administrator of the petroleum code. He decided then that there is entirely too much waste in the production of petroleum and natural gas, and though there has been decided improvemenr in production methods since that time, he still believes that the states have failed in their attempts to apply true conservation to the production of oil and that the Federal Government must step in and take over. At his suggestion, Interior Department officials early last summer drafted a new control measure and it was introduced in the House of Representatives by Congressman Cole, who explained that he was doing so at the request of the department.

The bill would establish a Federal Oil Commissioner who would be given authority to determine whether there is waste in the production of oil under state orders. In the event that wasteful production methods, as defined in the bill, are found, the commissioner would have the power to step in and take charge. Although the Cole Committee is studying all aspects of petroleum production, the real purpose of its present hearings is to determine the feasibility of the proposed measure.

While the bill has aroused a storm of protest from the officials of the major oil producing states, Ickes insists that it is designed solely for the purpose of insuring the utmost conservation of the nation's most valuable and irreplaceable resource, and so long as the states carry out their part, the Federal Government will not interfere.

Playing into Ickes' hand in the controversy was the failure of California recently to vote a state proration law, and the refusal to date of the Illinois Legislature to enact a production control measure. Although producers in California have voluntarily conducted a fairly successful control of the state's output, wells have run wild in Illinois and played havoc with the industry gen-

erally, as well as placing the state's flush fields in a position similar to those of early Oklahoma production.

Ickes and supporters of his bill also hold a strong card in the general shutdown of oil production last August by the major producing states, following a cut in posted crude prices by several of the large oil companies.

During the testimony of Colonel Thompson, who also holds the position of chairman of the Interstate Oil Compact Commission and in this role urged the general fifteen day shutdown that finally resulted in the restoration of prices, members of the TNEC wrested from him an admission that the price of crude petroleum, as well as conservation, plays a part in the administration of the state production control laws. Thompson, however, defended the consideration of price in enforcing the control by insisting that oil production below cost results in economic waste, almost as important as physical waste.

Representative Cole, author of the bill, has not yet decided whether its enactment is necessary or not, although he is not satisfied that state control has been completely successful. He recently told the A.P.I. that "there are those who believe that state regulation, after a reasonable period of trial, has failed in the matter of prevention of avoidable waste to the degree the nation should expect, and is not likely to prove effective in the future. But whether state regulation has failed to such an extent that the enactment of this legislation is necessary is a question on which I express no opinion. Perhaps our committee will be able to form an opinion."

Prospects for the enactment of the bill at this session of Congress, appear very slim. The states which produce the lion's share of the nation's oil output are in a position to exert tremendous pressure against the legislation. Nevertheless, the bill's consideration has awakened a new fear of federal control and there is definite evidence that the states, anxious to avert any such move, are doing everything they can to remove the criticisms against them and improve the methods of conservation in production control.

Price Situation

Although the prices of petroleum products have skyrocketed in other countries since the outbreak of the war, federal authorities as well as oil industry leaders see no material changes from present prices in the United States in the near future, aside from seasonal fluctuations.

The recent price increases in fuel oils were the result of a combination of developments and do not indicate a definite upward trend, officials of the Bureau of Mines believe. Oil executives, while not making any specific promises, tended to confirm this opinion during testimony before the TNEC, when they expressed the belief that all oil products will show future price declines because of improvement in production methods and lower distribution costs.

It is contended that the 1939 price rise for fuel oils was brought about by the general industrial pick-up which exceeded expectations and caught the oil industry somewhat short, coupled with an increase in tanker transportation rates from the Gulf Coast to eastern seaboard ports. As soon as production of fuel oil can again meet demand, which is expected during the winter months while gasoline consumption is low, and stocks can be replaced, a price cut may be expected.

Figures of the Bureau of Mines clearly show that the industrial spurt of 1939 exceeded the oil industry's expectations and forced the industry to withdraw large quantities of fuel oil from stocks, which always means a price jump. For instance, refinery stocks of gas oil and distillate fuels, or light fuel oil, in October totaled only 30,951,000 barrels as compared with 33,017,000 barrels in October 1938.

The reduction of stocks of residual, or heavy fuel oil, was even greater. In October, the refinery stocks amounted to 94,757,000 barrels as contrasted with 103,423,000 barrels a year ago. Even during October, the industry was still drawing on stocks to meet demands, for in September, they totaled 95,051,000 barrels.

Domestic demand for both types of fuel oil this year will undoubtedly far exceed the consumption during 1938, and in the case of the light oil, will probably establish a new record. The consumption of the heavy oil will probably be the highest since the depression, in the opinion of federal officials.

Preliminary Figures on Demand

While final figures will not be available for sometime, preliminary figures compiled for the first ten months of the year by the Bureau of Mines showed the demand for light fuel oils during that period to be 103,222,000 barrels as compared with 90,204,000 barrels during the same period in 1938, and the demand for residual oils totaling 260,987,000 barrels as compared with 234,555,000 barrels last year.

Exports of both types of fuel oil have likewise shown an increase, although not as much as might have been expected in view of the European war. For the same ten months period in each year, exports of light oils rose from 24,958,000 to 27,907,000 barrels and of heavy oils from 14,913,000 to 15,054,000 barrels.

The war, contrary to some expectations, has not had any immediate decided effect upon American oil industry and probably will not unless hostilities abroad continue indefinitely. Indirectly, however, the war has had a real effect upon the American oil business during the past five years as the major nations of the world prepared for the emergency they believed was coming, and is now at hand.

Although total exports of American petroleum and its products this year will almost certainly fall below exports during 1938, the period between 1933 and 1939 saw a heavy spurt in foreign buying of American oil, presumably for emergency stocks and to conserve the usual domestic supplies of the various nations.

Up through 1932, export sales of American oil showed a steady but not sensational increase. In 1933, however, heavy buying started, which reached an all-time peak in 1938. Crude exports, for instance, jumped from a total of only 27,391,000 barrels in 1932 to a record 77,272,000 barrels last year. There was no comparable percentage gain in all the previous years of the American oil industry. On the basis of figures for the first ten months of this year, however, crude exports will not exceed 75,000,000 barrels.

Exports of fuel oils from the United States did not reflect the emergency buying until 1934, when the total suddenly jumped from 18,455,000 barrels to 25,977,000 barrels. The increases continued and in 1938 the total had reached 43,832,000 barrels. Exports of fuel oils this year will probably be about the same as last, as they

are the only American oil products, except aviation gasoline, that have not shown a drop in foreign shipments. Through October, a total of 39,603,000 barrels of fuel oils had been exported, and if this pace is continued, the total for the year will at least reach if not exceed slightly the total for 1938.

The first reaction in oil circles after the war started was that there would be a heavy demand for American oil by the warring nations because of the importance petroleum now plays in military activities. Rear Admiral H. A. Stuart, director of the American naval petroleum reserves, stressing the necessity of adequate petroleum supplies by a warring country, told the Cole Committee:

"Any country, which has limited petroleum resources attempting an aggressive war, or fighting defensively, against a foe having access to practically unlimited supplies of oil, will be, even if it may possess some superiority in armaments, in the long run up against a disadvantage almost impossible to overcome."

Warring Nations Conserving Supplies

The warring nations, however, apparently decided that they would conserve their buying strength for other commodities for the time being. Instead of increasing their purchases of American oil, they virtually put a stop to the use of their existing supplies for any purpose except the war. Gasoline and fuel oils were put on a ration basis, not to be used except for absolute necessities. Coal and every other possible substitute for oil was put to use.

The war abroad, of course, revived the question of the United States halting its exports of this irreplaceable natural resource and conserving its entire supply for home use and national defense. This was proposed only recently by Secretary of Interior Ickes and Admiral Stuart, but met with a cold response from the industry and members of Congress, and nothing is expected to come of it in the near future, at least.

While Admiral Stuart and the War Department disclosed that in time of war, the petroleum needs of the army and navy would be increased some twelvefold, they estimated that wartime consumption by the two military branches would only be about 65,000,000 barrels a year. For a nation without its own petroleum supply, this would present a serious problem, but the amount, in terms of the American production rate of approximately 1,250,000,000 barrels annually, is comparatively negligible.

Germany and Japan are now utilizing processes of oil extraction from coal and shale on a large scale. Government witnesses before the Cole Committee estimated that Germany, through low-temperature carbonization of coal, hydrogenation, and synthetization, is now producing approximately half of its annual supply of petroleum. A recent report to the Commerce Department from Japan disclosed that the Japanese government has subsidized the Imperial Fuel Industry Company to produce large quantities of oil by the three methods, and has erected tariff barriers to make this production economically possible.

Research on these processes in the United States has kept pace with German and Japanese progress, officials declare, but so long as an adequate supply of crude petroleum exists, it would be useless to put them into operation. The cost, as yet, it was pointed out, is much higher than the production and refining of petroleum. It is estimated that gasoline produced in Germany from coal will cost between sixteen and eighteen cents a gallon. Costs in Japan appear to be similar.

In the United States, the cost could probably be reduced to twelve cents a gallon, one official estimated, but this is still too high under present conditions. Scientists who are engaged in such research, however, are confident that by the time this nation's crude supply begins to fall off, the process will permit the production of gasoline, fuel oil, and all other petroleum products from coal and shale at costs comparable to those for petroleum products today. And the supply of the low-grade coal and shale best suited to these methods in the United States are virtually limitless.

Imports of crude petroleum and fuel oils into the United States are expected to increase somewhat following the recent reduction of the import tax on petroleum through the reciprocal trade treaty between Venezuela and this country.

Although the fifty per cent cut in the tax, which is only applicable to an average of five per cent of the total amount of crude oil run to stills in the United States during the preceding calendar year, aroused a storm of protest among American oil men, it will not have any tremendous effect upon the domestic industry, in the opinion of impartial observers.

Imports of all petroleum to the United States prior to the treaty were averaging approximately 100,000 barrels a day, a little lower than earlier in the year, when they reached at one time 145,000 barrels daily. The tax reduction will only apply to approximately 175,000 barrels a day, which is five per cent of the daily amount run to stills in 1938. It appears doubtful that total imports during the next year or so, anyway, will run much over the amount permitted to come in under the reduced tariff.

Little Mexican Oil Imported

Since all of the oil imported from Venezuela, Colombia and the Netherlands West Indies, chief exporters of oil to the United States since the unofficial embargo on Mexican oil, is used largely for fuel oil, the increase may have a tendency to reduce fuel oil prices in the United States. Federal officials and industry executives, however, have declined to forecast the results until the treaty has been in operation for awhile.

There appears little chance that Mexico, which at one time exported substantial amounts of oil to this country, will enter the picture for some time to come. Since the expropriation of American oil properties in Mexico, the domestic oil industry has exerted an almost complete unofficial embargo on Mexican oil.

With little prospect that Mexico will settle for the properties at any time soon, President Roosevelt recently gave the embargo tacit approval in allocating quotas of imports at reduced taxes between various nations as provided in the Venezuelan treaty. In fixing the quotas, the President used import figures for the first ten months of 1939, rather than going back to a full previous calendar year. By using this basis, the President was obviously hitting at Mexico, since that nation shipped virtually no oil into the United States during 1939.

The Electric Light and Power Industry in 1939

By C. W. KELLOGG

President, Edison Electric Institute

The electrical output by central stations in 1939 was approximately 128 billion kilowatt-hours, which represented an increase of 12 per cent over 1938 and 38 per cent over 1929. Of this total, over 83 billion kilowatt-hours was produced by fuel-burning plants. New construction added 1,310,000 kw, and during 1940 and 1941 capacity will be further increased by 4,315,000 kw of which 2,830,000 kw will be in steam plants. The construction budget for 1940 is about $600,000,000.

THE electric light and power industry shared fully in the revival of business activity in this country which took place during 1939. Power output was up 12 per cent over 1938, 7 per cent above the previously high year of 1937, and exceeded that of the boom year of 1929 by 38 per cent.

Output of electricity in 1939 amounted to approximately 128,300,000,000 kwhr compared with 114,650,000,000 kwhr in 1938, with 119,810,000,000 kwhr in 1937 and 92,750,000,000 kwhr in 1929.

An outstanding feature of the year's operation was the substantial increase in output during the latter half of the year, resulting from the industrial expansion which accompanied the outbreak of war in Europe. The growth of total output of electricity from August to December showed an increase considerably above the usual seasonal increase for this period, but the relation of the December 1939 output to the August 1937 output corresponds closely to the long term trend of output growth of the industry and new capacity had been added during the two-year interval amply to provide for this increase.

Another feature of the year's operation was the serious shrinkage in water power production during the autumn months because of the progressive failure of water supply. Rainfall was deficient from the very start of the year; by September the drouth became acute and the year closed with many reservoirs empty or nearly so and the streams in some areas reduced to extreme low stage. Generation of electricity by water power during the last four months of the year ran 12 to 15 per cent below that of 1938 and for the year as a whole showed a decline of 4 per cent.

On the other hand, production of electricity by steam rose to new high records. The total for the year is estimated to have been 83,600,000,000 kwhr, an increase of 14,850,000,000 kwhr, or nearly 22 per cent over the year before. This steam power production almost equals the entire output of electricity from all sources during the boom year of 1929.

Sales of Electricity

Basing the figures on ten months' actual results (with November and December estimated) sales and revenues of electricity by the light and power enterprises of the country may be approximated as follows:

SALES TO ULTIMATE CONSUMERS

Classification	1939	1938
	Kilowatt-hours	
Domestic service	21,100,000,000	19,515,000,000
Small commercial	20,000,000,000	18,316,000,000
Large (industrial)	55,350,000,000	46,374,000,000
All other sales	10,550,000,000	9,689,000,000
Total	107,000,000,000	93,894,000,000
	Gross Revenues	
Domestic service	$ 859,000,000	$ 825,433,000
Small commercial	646,000,000	609,281,000
Large (industrial)	633,000,000	574,463,000
All other sales	166,000,000	163,063,000
Total	$2,304,000,000	$2,172,240,000

Industrial power sales were up nearly 20 per cent above 1938 and about 1 per cent above such sales in 1937. They were nearly 25 per cent above 1929. Commercial sales of small light and power also indicated an expansion of retail trade and showed a 9 per cent gain over 1938.

Domestic service showed the usual annual growth. A new high record was set at 21,100,000,000 kwhr, a gain of 8 per cent over 1938. The average use per customer increased from 853 kwhr in 1938 to 900 in 1939. It was 500 in 1929.

The grand total of electric customers on December 31 reached 28,750,000, an increase of 900,000 over the number at the close of 1938. Of these new customers 380,000 were farms, two-thirds of which were on REA lines, bringing the total number of electrified farms to 1,786,000, or approximately 28 per cent of all farms having occupied dwellings. About 1,400,000 of these farms were served by the industry.

Generating Capacity Installed

New construction in 1939 added 1,310,000 kw of generating capacity, of which amount 1,090,000 were installed by the industry and 220,000 by the Federal Government. The total generating capacity, including government power plants, amounted to 38,600,000 kw at the end of the year. In addition, about 670,000 kw of generating capacity in industrial establishments are interconnected with and contribute to the public supply of electricity.

OUTPUT AND CAPACITY

	1939	1938	1937
	(Millions of kilowatt-hours)		
Generation by fuel	83,600	68,765	74,206
Generation by hydro	39,400	40,926	40,960
Total generation	123,000	109,691	115,166
Purchased energy	5,320	4,956	4,645
Total output	128,320	114,647	119,811
	(Thousands of kilowatts)		
Industry capacity	37,466	36,330	34,960
Capacity supplying purchased energy	1,800	1,736	1,292
Total capacity	39,266	38,066	36,252

New construction programs as now planned for 1940 and 1941 will add 4,315,000 kw of additional capacity, of which amount 2,830,000 kw of steam capacity and 70,000 kw of additional hydroelectric capacity will be installed by the industry and 1,415,000 kw of hydroelectric capacity will be added by government projects.

Forty Per Cent Reserves in Industrial Areas

In the industrial areas east of the Mississippi and north and east of the state of Tennessee, electric utilities serving the industrial centers, which have a combined installed generating capacity of 22,385,000 kw, had reserve capacity amounting to 39 per cent, or 6,250,000 kw, in excess of the maximum load for the year. New construction programs for 1940 and 1941 will add 2,500,000 kw of steam capacity and 60,000 kw of hydroelectric capacity in these areas, an amount more than sufficient to maintain the present margin of reserves, which, in per cent, is now much broader than was the margin in 1917, at the time of the World War in Europe.

1940 Construction Budget

Construction budgets for the year 1940, according to preliminary reports, will amount to $600,000,000 exclusive of expenditures on Federal projects. Total construction expenditures for 1939, exclusive of Federal projects, are estimated to have been $450,000,000.

A National Grid

The mileage in the United States of transmission lines, carrying 33,000 volts and over, increased from 26,400 miles in 1917 to 89,000 miles in 1926, to 120,000 miles in 1929 and 146,000 miles in 1938. This mileage provides some measure of the degree to which interconnection of electric power supply sources has advanced. In the United States, this has been a progressive development governed by economic and service conditions. Its growth was not hampered by laws, such as blocked similar development for several decades in Great Britain. As a result there are several areas in this country covered with interconnected transmission systems reasonably comparable in area with that covered by the British Grid. This progressive development may be expected to continue, but the expanse of this country is so great and the consumption of power in the various industrial areas so large that in the interest both of economy and of reliability of service each area must be reasonably self-sufficient in its available generating capacity.

Rates, Revenues and Expenses

The price of electric service was reduced again during 1939 but at a smaller rate than has prevailed during previous years. It becomes more and more difficult to reduce rates in the face of mounting operating costs, rising taxes and increased charges for depreciation. At the end of 1939 the average price of electricity for domestic service stood at 4.07 cents per kwhr as compared with 4.23 cents in 1938, with 4.40 cents in 1937 and 6.33 cents ten years ago. The domestic customer's average bill is now just 10 cents per day as compared with $8^1/_2$ cents ten years ago, but in the meantime the amount of current per customer has nearly doubled.

Industrial power rates, due to the large increase in consumption, declined in average price in 1939 to the lowest point since the middle of the war emergency in 1917. Sales averaged 1.145 cents per kwhr as compared with 1.389 cents in 1929. Due to these reduced rates the revenues received from consumers showed a smaller rate of gain than did sales of electricity, and whereas kilowatt-hour sales increased 14 per cent during the year, revenues grew by only 6 per cent.

Total revenues approximated $2,304,000,000 for the year 1939, an increase of $132,000,000 over 1938. Many factors combined, however, to take large bites out of this added revenue, with the result that only about $50,000,000 of it was carried through to net income. The drouth made necessary the burning of much more coal and the price of coal and other materials showed some advance; taxes rose by about $20,000,000 to a new high figure estimated at $345,000,000, and represented 16.2 cents out of every dollar received from consumers; and charges for depreciation were also increased. Thus, net income showed a gain of about 10 per cent over the previous year but was still below that of 1929.

Comments on Financial Trends

It is interesting at this time to comment on certain long-time trends for appraisal of which one year is too short a period to be significant. It is now a decade since the market break of 1929 which ushered in the depression. During this decade the electric utilities have shown various basic changes that affect their fundamental position. In general, a gain of 18 per cent in gross revenue during the decade has been accompanied by a decrease in the earnings available for stockholders. Rate reductions produced a 17 per cent drop during the ten years in gross revenue per kilowatt-hour. The utilities have made strenuous efforts, through increased sales and operating economies, to offset this decrease in gross per kilowatt-hour and, despite an increase of 20 per cent in hourly labor cost during the decade, have succeeded in reducing the ratio of operating expenses to gross earnings from 39.3 per cent to 37.6 per cent. They have also benefited from the lower cost of bond money which has reduced from 14.0 per cent to 12.6 per cent the part of gross earnings required to pay interest charges.

The combination of operating economies, sales effort and reduced interest charges has been insufficient, however, to offset the growth during the decade in the cost of taxes and depreciation, the two combined now taking 27.5 per cent of gross revenue, whereas in 1929 they required but 18 per cent. The net result of all these factors was that the net income for the year just ended was 22.3 per cent of gross compared to 28.7 per cent in 1929.

Put in another way, during the decade net earnings of the electric utilities available for return on investment decreased $37,000,000, thus representing no return whatever on some $3^1/_2$ billions of capital investment made on private utility properties during the ten-year period.

Further Power Plant Standardization in Germany

For electric generating stations with condensing units the standardized steam conditions cover four pressures, two total steam temperatures and six turbine capacities. For topping turbines four capacities are prescribed. The standards cover most of the equipment entering into the power plant as well as feedwater temperatures, extraction stages and preferred station layouts.

COINCIDENT with the rapid growth of power demand in Germany during recent years, which resulted in active power plant construction, there sprung up a wide variety of equipment types, capacities and steam conditions. For instance, of sixty-five large boilers and twenty-one turbines sold in one year no two units were alike, except where installed in the same plant. This led to excessive engineering and construction costs, slower deliveries and the use of certain materials and machines, all of which could have been reduced by standardization. Also, it was felt that standardization would minimize and finally eliminate errors in calculations, planning and manufacture, reduce the number of experimental units, reduce the labor involved and permit both mass production and storage of component parts. The last-named factor was regarded as having prime importance as a defense measure in effecting speedy replacement of damaged parts.

Accordingly, early in 1936, a committee of the Verein deutscher Ingenieure working with the German Standards Commission brought out recommendations for standard steam conditions involving fifteen pressures and an incremental series of sixteen steam temperatures.[1] Since then, however, standardization has been carried much further, involving boilers, fittings, economizers, auxiliaries, piping and turbine-generators. Steam conditions for electric power plants have been fixed at four pressures, namely, 569, 910, 1138 and 1778 lb per sq in. and steam temperatures at 842 F and 932 F (the unusual figures corresponding to the metric system employed in Germany). Twelve capacities have been fixed, provision made for standardized types and rules promulgated for manufacture, for delivery and for relations between the manufacturer and purchaser. Certain exceptions or limitations are provided where additions to existing plants are concerned. In some cases it will be possible to have all the manufacturers establish similar types of equipment, whereas in others it will be necessary for each manufacturer to standardize his own types.

[1] See COMBUSTION, June 1936, p. 44.

These new standards are reviewed at length by Dipl.-Ing. H. Goerke in the October 1939 issue of *Archiv für Wärmewirtschaft und Dampfkesselwesen* from which the following review is taken.

Fig. 1 shows the boiler and turbine capacities correlated with pressures.

Steam at 125 atm (1778 lb) and 932 F represents, for the present, the highest that has been considered practical. According to European practice it involves reheating, and because of the debatable thermal advan-

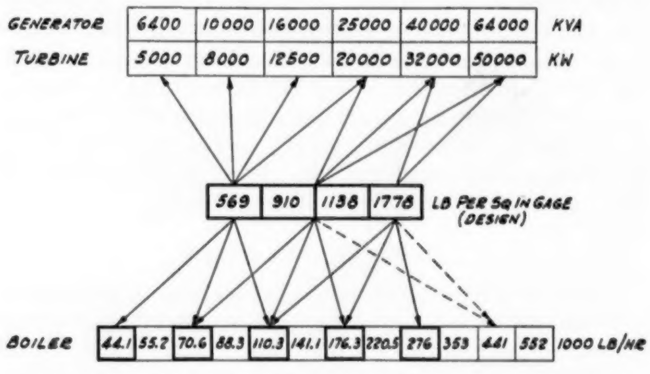


Fig. 1—Boiler and turbine capacities, also pressures

tage, many German power plant designers feel reluctant to employ such pressure. Therefore, the next lower steam condition was fixed as that at which the maximum permissible moisture in the steam within the last turbine stage, namely, about 12 per cent, would be realized without reheating. This was established as 80 atm (1138 lb per sq in.) and 500 C (932 F). For peak load conditions, standby stations for hydro plants, and for smaller units 40 atm (569 lb) and 932 F was decided upon, largely because under these conditions smaller condensing turbines operate at most satisfactory efficiencies. It is felt that pressures under 569 lb have only limited justification, such as in small industrial plants, heating plants and a few extensions to existing plants.

In determining turbine-generator capacities a power factor of 80 per cent was employed and a standard of generation at 10,000 volts was recommended.

The following feedwater temperatures were established:

Steam pressure, lb	1778	1138	910	569
Feedwater temp. (pulv. coal firing), deg F	392	374	374	302
Feedwater temp. (stoker or grate firing) deg F	302	302	302	302

Fig. 2 summarizes conditions for the boiler types. They include eleven bent-tube designs for brown coal and hard coals, as well as certain special types such as the Benson, La Mont and Schmidt-Hartmann. Additional

units for 441,000 lb per hr in the 1778 and 1138 lb classes are to be included.

Turbine-Generators

Standardization for turbine-generators has just begun. Difficulties lie in the basic differences in types and limitations in establishing types for each manufacturer separately. Six load groups for condensing turbines between 5000 and 50,000 kw and four between 5000 and 20,000 kw for topping have been recommended, whereas in the United States the preferred standards determined by the National Defense Power Committee about a year ago provide for nine load groups for condensing turbines between 10,000 and 100,000 kw, and seven for topping turbines between 10,000 and 60,000 kw.

For extraction and back-pressure turbines as employed in industrial plant service, standardization has proved especially difficult because of the great variety of applications and to date no definite recommendations have been made although the problem is being studied.

Plant Layouts

While an attempt has been made to standardize feedwater heating by stage bleeding, at present only the final temperatures have been established and the number of extraction points fixed. For pulverized-coal-fired boilers they are,

For 569 lb pressure................	3-stage heating up to 302 F
For 1138 and 910 lb pressure........	4-stage heating up to 374 F
For 1778 lb pressure...............	4-stage heating up to 392 F

With boilers having stoker or grate firing 3-stage heating up to 302 F is specified for all pressures.

Standard hook-ups are also recommended as shown in Fig. 3. In No. 1 feedwater is deaerated in the last stage in 3-stage heating with the advantages of having a uniform temperature of water delivered to the boiler, having the number and size of feed pumps chosen independently of the heater installation, and of having freedom in the design of the feed line leaving the feed pump. Since the temperature is 302 F, this scheme is suitable for all installations with stoker or grate firing and a steam pressure of 569 lb.

In schemes Nos. 2 and 3 two additional heaters are connected into the line leaving the feed pump, the first being connected to the third extraction point. Deaeration occurs at 302 F, as in scheme No. 1. The advantage lies in the higher efficiency realized and the lower water temperature for the feed pump by having the deaerator ahead of the last heating stage. Since tur-

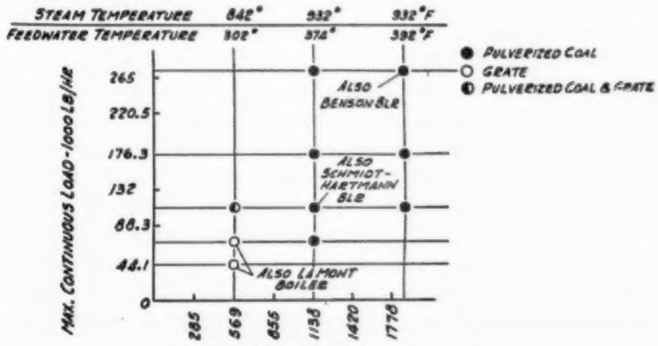


Fig. 2—Steam conditions and boiler types

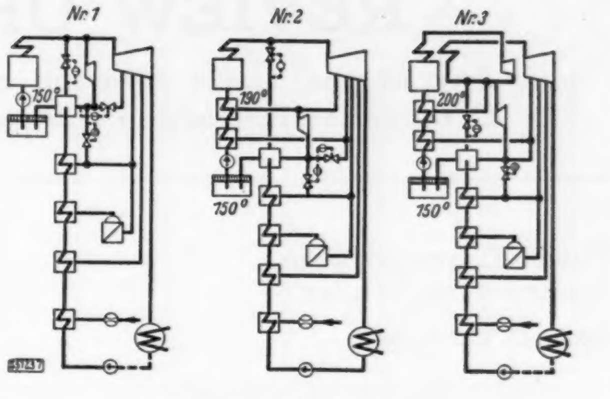


Fig. 3—Standard hook-ups

bines for which schemes Nos. 2 and 3 are intended, are of large capacities, are commonly run at high loads and are served by one or two boilers per turbine, the advantages of uniform feedwater temperature and greater freedom in pipe line and pump connections are not so marked. Where a house or auxiliary turbine exhausts into a heater, the corresponding main turbine extraction may be blanked off. Recommended extraction pressures are higher than those commonly employed in this country.

Feed Pumps

Recommendations are made for the choice of feed pump pressures and capacities, the former being about 15 per cent above the steam pressure. A water temperature of 302 F is specified. Fourteen pump capacities have been selected and it is recommended that in order to provide for overloads that in all cases the next larger size be selected to that corresponding to the boiler rating. For boilers with natural circulation the following pump delivery pressures are given:

Steam pressure, lb per sq in.	1778	1138	910	569
Pump delivery pressure, lb per sq in.	2050	1310	1050	655

Piping

Alloy steel is specified for piping operating under high pressures and high temperature. In the manufacture of such piping minimum charges in the electric furnace are fixed and the rolled lengths definitely stated. Surplus short lengths resulting from cutting the standard lengths in the process of fabrication must be used in various places where ordinary steel would suffice, in order to obviate wastage.

The number of pipe sizes, wall thicknesses and materials is restricted within four pressure groups, to a total of 38 different tubes. The first three groups, covering pressures of 910, 1138 and 1778 lb and 932 F temperature, deal with chrome-molybdenum steel having a cold tensile strength of 64,000 to 78,000 lb per sq in. and a permanent strength at 932 F of approximately 23,000 lb per sq in. For the fourth group, covering a pressure of 569 lb and 842 F, is specified a copper-molybdenum steel having a cold tensile strength of 54,000 to 64,000 lb per sq in. and a permanent strength at 842 F of 17,000 lb per sq in.

Similar standards are being prepared for feedwater lines and miscellaneous piping, as well as fittings.

Finally, normal layouts have been drawn up covering boiler installations, access doors, ash hoppers, headers, piping connections, etc.

REVIEW OF NEW BOOKS

Any of the books reviewed on this page may be secured from Combustion Publishing Company, Inc., 200 Madison Ave., New York

Power Economics for Engineering Students

By R. C. Gorham

Although economics now forms a part of the prescribed curriculum of most engineering schools, the subject is often taught in its broader sense without particular reference to engineering problems. On the other hand, the criticism is sometimes made that in teaching engineering subjects technical aspects are stressed to the slighting of economic considerations; whereas the two are inseparable, as is attested by the fact that engineering economics enter into all problems of the practicing engineer in the design of plants and the selection of equipment. To correct this and to train the student along the lines he will be called upon to reason when later engaged in engineering work, the author has prepared the present book.

The first ten chapters deal with basic considerations, such as money's worth, investment of capital, depreciation, obsolescence, standardization, safety and organization. This is followed by chapters on locating power plants and substations, load forecasting, selection of types, sizes of units and operating conditions, the determination of power costs, interconnection, load division, reserve capacity and rate schedules.

The book must be read for its methods of analysis rather than for the factual or design date presented. These are employed chiefly for illustrative purposes and are constantly changing. Also, exception may be taken to the fact that almost the entire section on boilers and steam pressures is given over to the Benson type to the exclusion of practice and trends in this country and the steam conditions employed.

There are 310 pages bound in cloth; price $4.

Wrought Iron (Second Edition)

By James Aston and E. B. Story

This 97-page book is intended to serve as a source of up-to-date information on wrought iron for those interested in problems of material selection and the preparation of engineering specifications, as well as for students in engineering schools.

It takes up the chemical composition and structural characteristics of wrought iron; its early manufacture and modern developments resulting from research. Present-day manufacturing methods are described and illustrated, quality standards are discussed, its forging, bending and welding covered and its various applications reviewed. The authors are, respectively, consulting metallurgist and chief metallurgist of A. M. Byers Company and therefore in a position to write authoritatively on the subject.

The price of the book is $1.

Internal Combustion Engines

By Lester C. Lichty

In the fifth edition of this well-known book the analysis of combustion and other thermodynamic processes has been very much simplified and numerous combustion charts included; the chapters on fuels, detonation and fuel injection have been entirely rewritten to agree with the results of recent research along these lines; and air-standard analysis has been treated in a separate chapter. Also, much has been added and the text brought up to date on materials, design, heat transfer and lubrication.

The book contains over six hundred pages, 6 × 9 in., fully illustrated and numerous tables. Price $4.50.

Gas Engine Handbook

This has been compiled by the Gas Engine Power Committee of the American Gas Association and, in addition to basic discussions of operating cycles, engine types, piston speeds, available power, carbureters, etc. The volume also contains much practical information on lubrication, ignition, exhaust systems, cooling systems, heat recovery, installation pointers and control. Many illustrations, diagrams and tables have been included and should prove most useful.

There are 58 pages, size 8$^1/_2$ × 11 in., with flexible cover. Price $1.

Combustion of Solid Fuels

This is a preprint of eleven papers presented as a symposium at the Boston meeting of the Gas and Fuel Division of the American Chemical Society. The topics covered range from chemical kinetics of combustion reactions to a consideration of the space required for the combustion of pulverized coal, and include several papers concerned with the measurement and significance of the ignitibility of solid fuel.

Among the outstanding papers of the group are (1) that by Hottel and Stewart, in which the measurements by Sherman of the progress of combustion, in powdered coal fired in an experimental furnace in which commercial conditions were simulated, are analyzed in the light of the mechanism of combustion of single particles elucidated in previous papers to yield a method of estimating the volume required for the combustion of powdered coal of known particle size distribution; and (2) that by Mott and Wheeler, which presents new experimental data on the rate of reaction of oxygen in air with the solids in a fuel bed and on the effect of particle size on that rate. Among the papers on ignitability are two, one by Seyler and Jenkins, and one by Mayers and Landau, which attempt to show the effect of the reactivity of the fuel on its behavior in burning.

The volume contains 117 text pages, mimeographed no one side only; price 75 cents.

Central Station Steam Generating Units of 1939

Ninety-one units for high and medium steam pressures are listed as completed, under construction or ordered during last year. High steam temperatures with bypass damper control, medium pressures, pulverized coal firing and use of heat-recovery equipment predominate. Approximately half of the boilers are of the three-drum bent-tube design and the remainder comprise several different and special designs. An appreciable number of units for new plants are noted. Refinements rather than wide departures from previous practice appear to mark the present trend.

THE ninety steam generating units listed in the accompanying tabulation as covering those of 700 lb design pressure and over, which were under construction, completed or ordered for central-station service during 1939, represent an aggregate steam capacity of over thirty-one million pounds of steam per hour. An additional unit, designed for 650 lb pressure, is also included because of certain unusual features. It is believed that the list is complete as regards units in this pressure range for the service indicated. While there have been a few central-station units furnished during this period for lower pressures they have been mostly to meet existing steam conditions in older plants and are therefore not typical of present practice. For this reason they have not been included. Those listed were, or are being, furnished by five boiler manufacturers, namely, Combustion Engineering Company, Babcock & Wilcox Company, Foster Wheeler Corporation, Riley Stoker Corporation and Springfield Boiler Company, to all of which acknowledgment is made for cooperation in furnishing the information contained in the table. Units for installation in South America are not included.

It will be noted that the proportion of superposed units was somewhat less than in 1937,[1] evidently because so many of the older low-pressure plants in the 200 to 250-lb pressure range that were susceptible to economical topping have now been modernized in this manner. A number of extensions to these plants will be found and the appreciable number of new plants, namely, eighteen, would indicate that an era of new plant construction has begun. Many of these are in the 700 to 900-lb class.

As for design pressures, there is one installation listed at 2650 lb; thirty-three units are for 1400 to 1500 lb; twenty-six are in the 800 to 1000-lb range; and thirty-one in the 700 to 800-lb class. Approximtely two-thirds of the units employ total steam temperatures of 900 F and over, thus indicating a definite trend toward more extensive use of these high steam temperatures, regardless of the pressures employed.

Of the boiler types represented the multi-drum bent-tube design appears to predominate with forty-four such units. Next come nineteen units of the radiant type, ten of the two-drum, bent-tube type, nine of the cross-drum straight-tube design, three of which had been ordered several years previously and construction deferred, seven of the open-pass design and two of special design employing a twin furnace. In one of these units, the furnaces are fired separately, one for producing superheat and the other for steam generation—a practice not uncommon in marine installations but believed to be the first in land service for power generation, excluding, of course, a separately fired superheater.

For superheat control the use of bypass dampers finds wide acceptance, seventy-three out of the ninety units being so equipped. Only four employ desuperheaters, differential firing is used in three cases, one has a separately fired superheater, one employs a combination of radiant and convection superheaters and the remaining units have no superheat control.

Over Two-thirds Burn Pulverized Coal

Firing with pulverized coal is employed in sixty-three cases, four of which burn anthracite; only eight units are stoker-fired and the remainder burn oil or gas. It will be noted that in many of these provision has been made for burning pulverized coal, oil or gas as alternate fuels or for future use. The types of burners vary, depending upon the character of the fuel and the design of furnace.

While there has been a marked increase in the number of slagging bottom furnaces, of which twenty-four are of the continuous-drip type and five of the intermittent-tap type, the total is exceeded by furnaces of the dry-bottom type, of which there are thirty-nine. Here again, the fluid temperature of the ash in the coal, the character of the load and the size and type of unit are determining factors.

As would be expected with the application of higher pressures and steam temperatures, employment of heat-recovery equipment has become quite general. In all except three cases air preheaters are used, with the regenerative type predominating, and with two-thirds of the units economizers are also employed.

In general, the tabulation shows no disposition to exceed or even equal, the capacity of a few very large units previously built, and those of medium output appear to be in the majority, especially as concerns the new plants. Furthermore, with one exception, they do not depart from previously well-tried steam conditions. Refinements rather than innovations in design are embodied in the units listed. From this it would seem that the tendency, for the present at least, is to capitalize on the experience gained during the past few years, rather than to attempt any marked departures from current practice.

[1] See COMBUSTION, July 1937.

Steam Generating Units of 700 Lb Pressure and
Ordered, Under Construction or Plac

Station	Company	Boilers	Capacity, Each Lb per Hr	Design Press. Lb per Sq In.	Total Steam Temp., F	Type of Boiler	Superheat Control
Oswego	Cent. New York Pr. Corp.	2	900,000	1500	903	Radiant	Bypass dampers
Windsor	Ohio Pr. Co.	1	750,000	1525	925	Special	Differential firing
Waterside	Consolidated Edison Co., N. Y.	2	615,000	1475	925	3-drum, B.T.	Bypass dampers
Waterside	Consolidated Edison Co., N. Y.	2	615,000	1485	925	Open-pass	Bypass dampers
Chester	Philadelphia Elec. Co.	2	600,000	1450	935	Open-pass	Bypass dampers
Marion	Pub. Serv. Elec. & Gas Co., N. J.	2	550,000	1475	950	Radiant	Bypass dampers
Burlington	Pub. Serv. Elec. & Gas Co., N. J.	2	550,000	1475	950	Radiant	Bypass dampers
Twin Branch	Indiana & Michigan Elec. Co.	1	550,000[1]	2650	940	Open-pass	Desuperheater and bypass dampers for reheat control
Buzzards Point	Potomac Elec. Pr. Co., Wash., D. C.	1	525,000	775	900	3-drum, B.T.	Bypass dampers
Lake Shore	Cleveland Elec. Ill. Co.	2	500,000	1000	910	Open-pass	Bypass dampers
Manchester St.	Narragansett El. Co. (Providence)	1	430,000	1350	915	3-drum, B.T.	Bypass dampers
Northwest	Commonwealth Ed. Co., Chicago	3	425,000	1425	935	3-drum, B.T.	Bypass dampers
Delray	Detroit Edison Co.	3	424,000	950	910	3-drum, Stirling	Bypass dampers
Conners Creek	Detroit Edison Co.	3	420,000	710	840	Double-set, B.T.	Compensating type with damper control
12th Street	Virginia El. & Pr. Co., Richmond	1	400,000	925	835	3-drum, B.T.	Bypass dampers
Newcastle	Penn. Pr. Co.	1	400,000	900	900	3-drum, B.T.	Bypass dampers
Cliffside	Duke Power Co.	2	400,000	900	900	3-drum, B.T.	Bypass dampers
Buck	Duke Power Co.	2	400,000	900	900	3-drum, B.T.	Bypass dampers
John C. Weadock (Bay City, Mich.)	Consumers Pr. Co.	2	400,000	900	900	3-drum, B.T.	Bypass dampers
Chickasaw (Mobile)	Alabama Pr. Co.	1	400,000	950	860	3-drum, B.T.	Bypass dampers
Bryce E. Morrow (Kalamazoo, Mich.)	Consumers Pr. Co.	2	400,000	900	900	3-drum, B.T.	Bypass dampers
Macon	Georgia Pr. Co.	1	400,000	950	860	3-drum, B.T.	Bypass dampers
Toronto	Ohio Edison Co.	1	400,000	900	900	Radiant	Bypass dampers
Commerce St.	Wisconsin Elec. Pr. Co.	1	375,000	1400	900	3-drum, B.T.	Comb. conv. and rad. superheaters
L. Street	Boston Edison Co.	2	375,000	1400	910	3-drum, B.T.	Bypass dampers
Millers Ford	Dayton Pr. & Lt. Co.	2	375,000	1375	900	Cross-drum, high head	Bypass dampers
Peoria	Central Illinois Lt. Co.	1	375,000	900	900	3-drum, B.T.	Desuperheater
		1	300,000	900	875	3-drum, B.T.	Desuperheater
Powerton (Ill.)	Commonwealth Ed. Co.	2	450,000	732	750	Cross-drum, sect. hdr.	None
		1	290,000[3]	732	750	Cross-drum, sect. hdr.	None
Lake Road	City of Cleveland, O.	3	350,000	750	835	3-drum, B.T.	Bypass dampers
Cedar Rapids	Iowa El. Lt. & Pr. Co.	1	300,000	750	780	Cross-drum, sect. hdr.	None
		1	250,000	750	765	Cross-drum, sect. hdr.	None
Westport	Cons. Gas & El. Co., Baltimore	2	285,000	1450	915	3-drum, B.T.	Bypass dampers
Dresser	Dresser Pr. Corp., W. Terre Haute, Ind.	2	250,000	775	910	3-drum, B.T.	Bypass dampers
Goble Street	Houston Lt. & Pr. Co.	1	250,000	975	910	3-drum, B.T.	Bypass dampers
Station No. 3	Rochester Gas & El. Corp.	1	250,000	750	775	4-drum, B.T.	None
Ottawa St.	City of Lansing, Mich.	2	225,000	950	900	Cross-drum, high head	Bypass dampers
E. Wells St.	Wisconsin El. Pr. Co.	1	225,000	725	825	3-drum, B.T.	None
Evansville, Ind.	So. Ind. Gas & El. Co.	1	225,000	900	900	3-drum, B.T.	Bypass dampers
Avon (Calif.)	Pacific Gas & Elec. Co.	3	200,000	1525	950	Radiant	Bypass dampers
Martinez (Calif.)	Pacific Gas & Elec. Co.	3	200,000	1525	950	Radiant	Bypass dampers
Oleum (Calif.)	Pacific Gas & Elec. Co.	3	200,000	1525	950	Radiant	Bypass dampers
Municipal Plant	City of Glendale, Calif.	2	200,000	750	825	2-drum "VU" type	Bypass dampers
Blount St.	Madison Gas & El. Co. (Wis.)	1	200,000	975	825	Radiant	Bypass dampers
Walnut (Groveport, Ohio)	Columbus & So. Ohio El. Co.	2	200,000	1475	900	Radiant	Bypass dampers
Abilene	Kansas Pr. & Lt. Co.	1	190,000	900	835	3-drum, B.T.	Bypass dampers
Rockford	Cent. Ill. El. & Gas Co.	1	175,000 (initial) 190,000 (future)	725[4]	750 (initial)	2-drum, Integral Furnace[5]	Desuperheater (future)
Hutsonville	Cent. Ill. Pub. Serv. Co.	2	150,000	725	835	2-drum B.T. "VU"	Bypass dampers
Derby, Conn.	Derby Gas & El. Co.	2	125,000	725	750	2-drum, Integral Furnace	None
Moose Jaw, Sask.	Natl. Pr. & Lt. Co.	1	120,000	650	850	2-drum, 2 fur.	Differential
Oil City, Pa.	Keystone Pub. Serv. Co.	1	100,000	725	750	Twin fur.	Differential
Alexandria, Va.	Virginia Pub. Serv. Co.	2	80,000	725	850	3-drum, B.T.	None
Lawrence, Kans.	Kansas Elec. Pr. Co.	2	60,000	700	850	2-drum, B.T.	Bypass dampers

[1] Plus 440,000 lb of steam reheated from 490 to 760 F at 190 lb abs.
[2] Condensing turbine, extraction steam to low-pressure line.
[3] Plus 828,000 lb of steam reheated from 545 to 900 F at 435 lb abs.
[4] Initial operation at 275 lb.
[5] Has one open pass.

nd Over for Central Station Service,
laced in Service during 1939

Fuel	Method of Firing	Type of Furnace	Econo-mizers	Air Heaters	New Plant, Addition or Superposed Installation	Remarks
Pulv. bit. coal	Intertube burners	2-stage cont. drip	Yes	Tubular	New	One unit installed 1939, one ordered 1939
Pulv. bit. coal	Horizontal	Twin, dry bottom	Yes	Yes	Superposed	Placed in service early in 1939. A unit of like capacity but different design, went into service late in 1938
Pulv. bit. coal	Tangential	Continuous slag drip	Yes	Regenerative	Superposed	2 under construction 1939 for completion in 1940
Pulv. bit. coal	Intertube burners	Continuous slag drip	Yes	Regenerative	Superposed	Scheduled for completion 1941
Pulv. bit. coal	Intertube burners	Continuous slag drip	Yes	Regenerative	Superposed	
Pulv. coal-oil	Intertube burners mech. atom, oil	2-stage cont. drip	Yes	Regenerative	Addition	
Pulv. coal-oil	Intertube burners mech. atom, oil	2-stage cont. drip	Yes	Regenerative	Addition	
Pulv. bit. coal	Intertube burners	Continuous slag drip	Yes	Tubular	Addition	Ordered 1937, released for fabrication 1939
Pulv. coal, nat. gas or oil	Tangential	Continuous slag drip	Yes	Regenerative	Addition	
Pulv. bit. coal	Intertube burners	Continuous slag drip	Yes	Regenerative	Addition	
Pulv. coal-oil	Horizontal	Dry bottom	Yes	Regenerative	Superposed	Ordered 1937, construction deferred till 1939
Pulv. bit. coal	Tangential	Continuous slag drip	Yes	Tubular	Superposed	
Coal & blast fur. gas	Underfeed stoker	...	Yes	Tubular	Addition	Two similar units placed in service, 1938; 3 units have gas burners
Coal	Opposed underfeed stokers	...	Yes	Plate	Rebuilt	These 3 units, installed 1939, complete the 11 units in rebuilt plant
Pulv. bit. coal	Tangential	Intermittent slag tap	None	Regenerative	Superposed	Duplicate of unit installed in 1937
Pulv. bit. coal	Horizontal	Dry bottom	Yes	Yes	New plant	
Pulv. bit. coal	Tangential	Dry bottom	None	Regenerative	New plant	
Pulv. bit. coal	Tangential	Dry bottom	None	Regenerative	Addition	
Pulv. bit. coal	Horizontal	Dry bottom	Yes	Yes	New plant	
Pulv. bit. coal	Tangential	Dry bottom	None	Regenerative	Addition	
Pulv. bit. coal	Horizontal	Dry bottom	Yes	Yes	New plant	
Pulv. bit. coal	Tangential	Dry bottom	None	Regenerative	New plant	
Pulv. bit. coal	Cross tube	Intermittent slag tap	Yes	Tubular	Addition	Ordered 1937, released for fabrication 1939
Pulv. bit. coal	Vertical	Dry bottom	None	Plate	Addition	
Pulv. bit. coal	Horizontal	Dry bottom	Yes	Regenerative	Superposed	
Pulv. bit. coal	Cross-tube	Hopper bottom	Yes	Tubular	Superposed	
Pulv. bit. coal	Horizontal	Hopper bottom	Yes	Yes	New	
Pulv. bit. coal	Horizontal	Hopper bottom	Yes	Yes		
Pulv. bit. coal	Cross-tube	Intermittent slag tap	Yes	Tubular	Addition	Ordered 1929, released for fabrication 1939
Pulv. bit. coal	Cross-tube	Intermittent slag tap	Yes	Tubular	Addition	
Pulv. anth.	Horizontal	Dry bottom	No	Yes	New plant	
Pulv. bit. coal	...	Center wall fur., dry bottom	Yes	Regenerative	Addition	
Pulv. bit. coal	...	Center wall fur., dry bottom	Yes	Regenerative	Superposed	
Pulv. bit. coal	Horizontal	Dry bottom	Yes	Regenerative	Superposed	
Pulv. bit. coal	Tangential	Continuous slag drip	Yes	Tubular	New plant	
Oil & gas	Horizontal	Air cooled	Yes	Yes	New plant	
Pulv. bit. coal	Horizontal	Dry bottom	Yes	None	Addition	Similar to 3 units installed in 1935, 1937 and 1938
Pulv. bit. coal	Intertube burners	2-stage, slag tap	Yes	Regenerative	New plant	
Pulv. bit. coal	Vertical	Dry bottom	None	Plate	Addition	
Pulv. bit. coal	Horizontal	Dry bottom	Yes	Yes	Superposed	
Gas, oil, acid sludge[6]	Oil burners	Fut. slag tap	Yes	Tubular	New plant	These units will operate in connection with 3 oil refineries
Gas, oil, acid sludge[6]	Oil burners	Fut. slag tap	Yes	Tubular	New plant	
Gas, oil, acid sludge[6]	Oil burners	Fut. slag tap	Yes	Tubular	New plant	
Oil & gas	Horizontal	...	None	Regenerative	New plant	
Pulv. bit. coal	Intertube burners	2-stage slag drip	Yes	Regenerative	Superposed[3]	
Pulv. bit. coal	Intertube burners	2-stage slag drip	Yes	Regenerative	Superposed[3]	
Nat. gas or oil future pulv. coal	Horizontal	Dry bottom	None	Regenerative	New	
Pulv. bit. coal	Horizontal	Hopper bottom	None	Regenerative	Addition	825 F future steam temp.
Pulv. coal-oil	Horizontal	Dry bottom	None	Tubular	New plant	
Pulv. bit. coal-oil	Horizontal	Half hopper	None	Tubular	Superposed	
Gas & oil	Horizontal	Sep. fired[7]	None	Regenerative	Superposed	
Pulv. bit. coal	Horizontal	Dry bottom	Yes	None	Addition	
Coal	Stoker	...	None	None	Addition	
Gas & oil	Horizontal	...	None	Yes	New plant	

[6] Future, pulverized petroleum coke.
[7] The two furnaces are separately fired, one for steam generation and the other for superheat. Because of this unusual arrangement in land practice this unit is included although the pressure is below 700 lb.

Port Washington Station Sustains Its Economy

In view of the outstanding performance of Port Washington Station of the Wisconsin Electric Power Company, which since its initial operation has maintained the world's record for economy, it has been the practice of Combustion for several years to report the performance for the preceding twelve months.[1] The report for 1939 is more condensed than that of former years. The station heat rate for the year was 10,770 Btu per kwhr at 59 per cent load factor, which was 0.2 per cent better than 1938, thus continuing an unbroken downward economy trend. The boiler and turbine availabilities were 93.4 and 93 per cent, respectively.

SIX months' continuous operation under load, followed by scheduled outage for inspection, was perhaps the most important experience of the fourth year of operation at Port Washington. Load conditions were such that no week-end outages due to lack of system load were required from Oct. 17, 1938 to Apr. 22, 1939, resulting in a continuous run of 6 months 5 days.

Recurrence of screen-tube corrosion was probably the second most important experience. After $2^1/_2$ years of corrosion-free operation, a screen tube failed on August 31, and fifteen adjacent tubes were found thinned in much the same manner as previously described.[2]

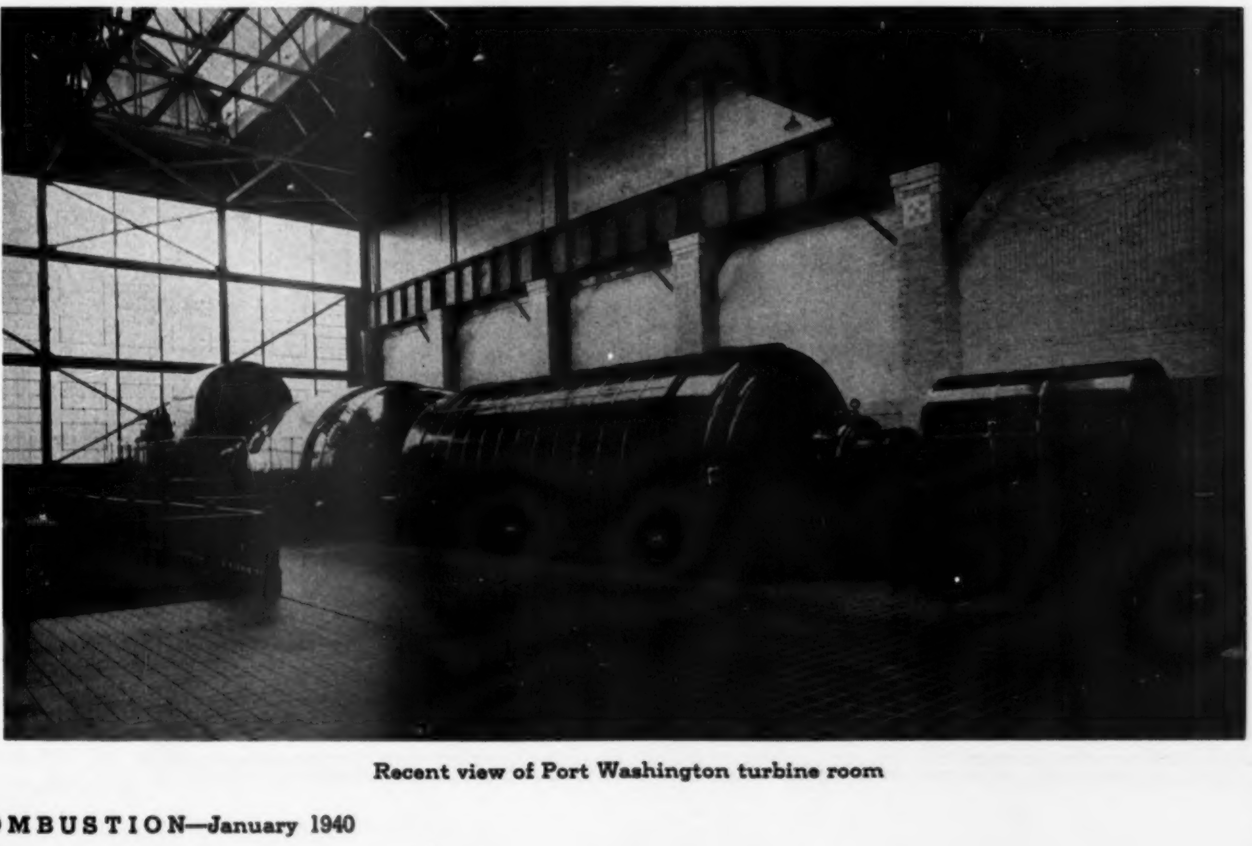
Previous inability to inspect the tubes without their removal and destruction, the difficulty of re-establishing protective coatings on new tubes replacing the inspected ones, and the sustained low rate of corrosion as measured by hydrogen in the steam had discouraged inspection that was sufficiently adequate to sense the apparently slow corrosion before tube failure. Concentration of only about one ounce per day corrosion on limited areas removed about 50 lb of metal in the $2^1/_2$ years.

Use of recently developed inspection methods (test drilling and electrical thickness testing), application of additional chemical correctives and the making of six minor physical changes have afforded better assurance that the trouble will not recur. Checking of tube thickness at more than one hundred points in the corrosion area on November 25 proved that there was no important corrosion during the previous $2^1/_2$ months' operation after replacing the sixteen tubes.

That the basic corrosion cause is not primarily physical is indicated by the definite responsiveness of corrosion rate to various chemical treatments. Injection of only one pound of tannic acid powder increased corrosion rate sixteen times after the six physical changes had been made. Injection of sodium bichromate on many subsequent occasions has always consistently resulted in marked reduction of the corrosion rate. Previously de-

[1] See "Design Features of the Port Washington Power Plant, by G. G. Post, A. I. E. E. paper, June 1933, and Combustion, August 1933; "The Port Washington Plant," by F. L. Dornbrook, *Mechanical Engineering*, November 1936; "Port Washington's Second Year," Combustion, February 1938; and "Port Washington's Third Year," Combustion, January 1939.

[2] Combustion, February 1938.



Recent view of Port Washington turbine room

scribed principles and practices have been confirmed by these more recent experiences, all of which have emphasized the vital rôle of natural protective coatings in high-pressure boilers.

The outage of April 27 to May 17 was extended a week to improve the silver-soldering of turbine-blade shrouding in the two high-temperature sections of the high-pressure spindle. Upon scheduled inspection of the high-pressure turbine after 16,700 hr operation since the previous inspection, several shroud sections were found removed, and many soldered joints evidenced the beginning of failure by cracking of the solder at a maximum stress point. Creep of the solder at 800 F (half of its melting point of 1600 F) is apparently as important as that of other metals at approximately half of their melting points. Inadequate short-time strength at high stresses, higher-than-steam temperatures induced by rubbing, and the quality of the soldering technique all shared responsibility for the failures. Improved joints were made on thirty-five rows.

The low-pressure spindle, inspected after 8000 hr because of the opportunity afforded by work on the high-pressure section, was found entirely satisfactory. Turbine efficiency continues to be accurately sustained at previous high levels, as does the condenser performance.

Boiler and turbine availabilities were again almost identical; 93.4 and 93.0 for 1939 and 94.1 and 94.3 for the four years. The accompanying table shows outage, load and heat consumption data for 1939 and for the 4.1 years since the plant was started.

Boiler-feed pump internal leakages between both stationary and rotating parts have resulted in minor decreased output and poorer station efficiency at the most economical load, but recent minor changes and plans give promise of correcting these faults. The pumps have been highly reliable, but accurate maintenance of peak efficiency and economy has yet to be proved.

Pressures, temperatures, fuel data and all other operating conditions and results have remained closely to those reported for previous years, which similarity prompts omission of the previously published tables.[3] Maintenance costs have likewise remained consistently low.

[3] COMBUSTION, February 1938 and January 1939.

PORT WASHINGTON OUTAGE, OUTPUT AND HEAT CONSUMPTION DATA

4.1 Year Summary From Nov. 22, 1935, to Dec. 26, 1939	% of Time	1939 Monthly Output and Heat Consumption Data: Month	Million Kwhr, Net	Btu/Net Kwhr
Elapsed time (35,904 hr) 100%				
Plant operated (31,576 hr)	87.9	Jan.	38.1	10,776
Outages, scheduled	6.1	Feb.	34.6	10,795
Lack of load	2.3	Mar.	38.7	10,784
Mechanical trouble	1.2	Apr.	38.3	11,067
Corrosion trouble	2.5	May	10.6	11,054
		June	33.9	10,725
Total outages	12.1	July	36.5	10,615
Plant availability	90.2	Aug.	39.7	10,591
Output, million kwhr, gross	1,680	Sept.	19.5	11,275
Output, million kwhr, net	1,593	Oct.	31.0	10,778
Average load, kw	53,201	Nov.	39.2	10,666
Peak load, kw	82,000	Dec.	41.3	10,655
Load factor, %	58.5	1939	391.3	10,770
Heat consumption, Btu/net kwhr (1936—10,954; 1937—10,835; 1938—10,788)				

1939 Outages—April 22 to May 17, for scheduled inspection; August 31 to September 9, screen-tube failure; October 3 to 8, for 6 minor screen-tube changes; November 25 to 26, screen-tube inspection.

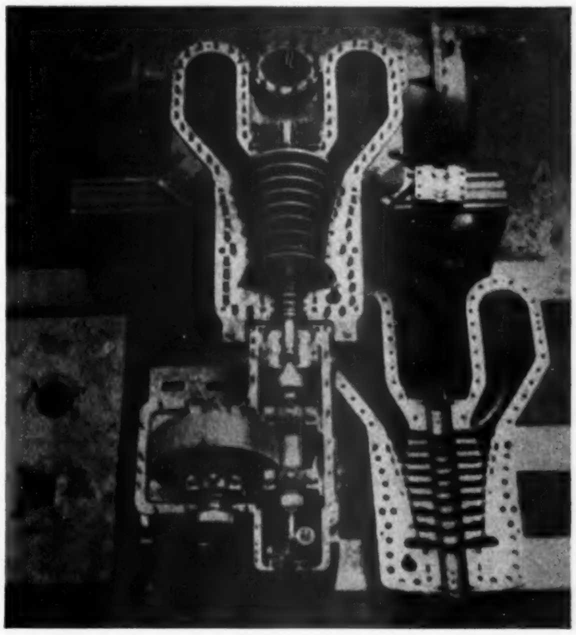
STEAM ENGINEERING ABROAD

As reported in the foreign technical press

Simplified Turbine and Condenser Arrangement

Industrial Power and Fuel Economist (London) for November prints a description, by its Zurich correspondent, of an Escher Wyss turbine having an unusual condenser arrangement which eliminates the necessity for a deep basement. It is suitable for units up to about 1500 kw capacity.

As indicated in the accompanying illustration, part of the condenser casing is cast integral with the turbine



Looking down on unit with top half of turbine casing removed

casing with the tubes at right angles to the turbine rotor. The exhaust steam leaving the last stage of the turbine is divided into two paths and enters the condenser over approximately half its length. To allow for expansion the rear end of the turbine rests on cast-iron slide plates embedded into the concrete foundation.

Some Coal Statistics

According to an address by Prof. P. O. Rosin, reproduced in the *Journal* of The Institute of Fuel (Great Britain) for October, the total coal production of the world in 1938 was 1454 million metric tons (2205 lb) of which 1189 million tons was bituminous coal. This represented an increase of 8 per cent over that of 1913. The world's coal deposits down to 6000 ft are estimated at 4.68 billion metric tons of bituminous and 3.06 billion tons of brown coal, which combined is about 53,000 times the 1938 production.

Of the 1938 output, Europe produced nearly 55 per cent and North America 30.5 per cent, leaving only 14.5 per cent for the other continents. The United States accounted for 96 per cent and Canada for 2.7 per cent of that mined in North America, although the estimated resources of the former are 72 per cent and those of the latter 22 per cent.

Europe's production of 654 million tons was divided as follows: Great Britain 35.4 per cent, Germany 28.5 per cent, Russia 13.3 per cent, France 7.1 per cent, Poland 6 per cent, Belgium 4.5 and all the other countries combined 5.2 per cent.

The distribution of coal deposits varies greatly in different countries, those in England covering 12,000 sq mi, or nearly 13 per cent of the total surface area of that country, thus making the transportation to various industrial centers comparatively short. This is much more favorable than in Germany and the United States where concentrations of deposits involve long hauls to some industrial centers.

Operation of the Grid in England

In his presidential address before the Institution of Electrical Engineers, Johnstone Wright gave some interesting observations on the construction and operation of the British Grid. His address is reproduced in abridged form in *Engineering* of November 24, from which the following is taken:

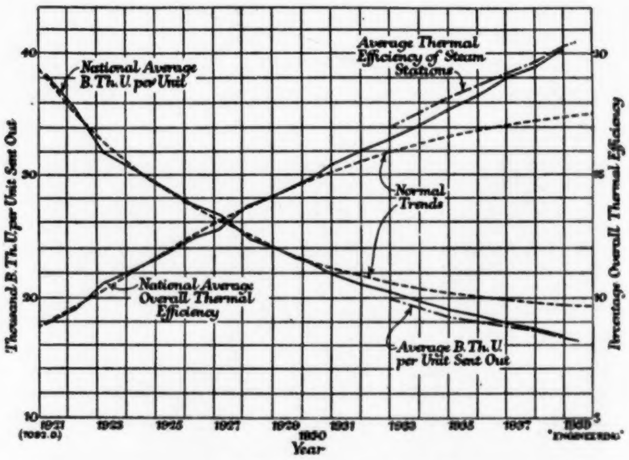
During the pre-Grid period the amount of spare plant to provide against possible breakdowns had been increasing steadily with the larger size of units, but since 1933 the trend has been steadily toward less reserve.

Apart from the savings in capital charges it has been possible to allocate the load in accordance with cost efficiency, enabling selected stations to be run for long periods and the least efficient ones to be relegated to peak-load duty. For instance, in 1938 only 30 of the 171 generating stations under direction of the Board were kept running throughout the year; 14 of the most economical stations supplied 50 per cent of the total output; and 52 stations were run less than 2400 hr. As a result of this allocation of load the average economy of generation was reduced as shown by the accompanying curves. Unfortunately, the savings due to improved thermal efficiency have been largely offset by the rise in price of fuel since 1935.

The general adoption of higher steam pressures and temperatures is rapidly diminishing the relative difference in cost efficiency between stations with abundant

cooling water and those with cooling towers. Broadly speaking, riverside stations have the lowest capital costs while stations on coastal estuaries have the highest capital costs owing to the expensive civil engineering work required. With modern high efficiency cooling towers, re-cooled temperatures of 75, 70 and even 65 F are possible under prevailing conditions.

The establishment of the Grid has drawn attention to the influence of boiler availability on capital and operating costs. There is a wide gap between the average availability of the turbine-generators and the boilers. Investigations have shown that where high gas velocities were employed in the economizer and air preheater sections, rapid fouling occurred with certain coals and in some cases the draft loss increased 10 per cent in under 400 hr. In the more recent types of boilers the adoption



Average economy of British power stations supplying electricity to the Grid

of larger combustion chambers, coupled with an increase in the amount of heat absorption by radiation and a reduction in the amount absorbed by convection, has led to improvement in availability. Recent experience gained in a high-head type of stoker-fired boiler shows that after 2500 hr continuous operation, during which fourteen different brands of coal were burned, it was possible to obtain 25 per cent overload, although the gas passages had been cleaned by soot blowers only.

With reference to flue gas washing to remove sulphur, Mr. Wright pointed out that, based on experience with the two large existing installations, the capital cost of a station so equipped will be increased by 2£ (between $9 and $10) per kw, and may add 0.02 d. (0.4 ml) per kwhr generated. Also, it will increase the auxiliary power by about 1 per cent of the station output.

The total installed capacity in 1927 was approximately 5,200,000 kw. Since then 5,700,000 kw additional capacity has been installed or ordered for installation up to 1942 involving a capital expenditure equivalent to nearly 400 million dollars.

Rolled-in Condenser Tubes

The October issue of *The Brown Boveri Review* (Switzerland) discusses the rolling-in of condenser tubes at both ends and the treatment of the tubes prior to their insertion into the condenser. In line with the practice of

many companies in the United States, it has been the regular custom of Brown Boveri for more than ten years to expand the tubes into the tube plates, which are rigidly attached to the shell, and to employ electric welding for fabrication of the shells. The tubes, in the form of an elongated *S*, rest in sagging plates at the nodal points, the deflection being in a horizontal plane. Bending is effected by means of three adjustable rollers and care must be taken to insure that the curves are all in the same plane. In order to allow for drainage the tubes, during mounting, are given a slight upward set, which is achieved by an appropriate eccentricity of the sagging plates. Expanding is accomplished by means of a special tool with automatic limitation of both the stroke and the pressure.

Tests and experience have shown that the exact composition of the alloy used for condenser tubes is of secondary importance, provided the crystal structure is uniform and that the metal has been subjected to the correct heat treatment, but tubes in which internal strains were present have shown marked tendencies to corrosion. Tubes with packings and ferrules must be hard to resist collapse and are therefore more likely to have strains unless these be eliminated by careful heat treatment without affecting the strength of the material. On the other hand, where both ends are rolled-in it is permissible to soften the material by heat treatment.

While the expanding process implies a certain amount of stressing of the metal, numerous tests have shown that hard tubes invariably exhibit a small negative electrolytic potential difference between the expanded part and the remainder of the tube; whereas with soft tubes this potential difference is smaller and finally disappears.

Sulphur Extraction

"The cost of installing an efficient plant for extracting noxious gases and fumes from chimney emissions may be a decisive factor in the future choice of sites for new power stations," says *The Electrical Times* of Nov. 23, 1939. Battersea Station of the London Power Company and Fulham Station, both located in densely populated areas, have each had to pay about $1,200,000 for sulphur extraction systems, in addition to the annual fixed charges, cost of operation and maintenance. However, the reported efficiency of extraction has been high. With coal averaging 0.8 per cent sulphur the discharged gases at Battersea contain about 0.03 grain of sulphur compounds per cubic foot of dry gas and at Fulham, which was of later design, the average total acidity after treatment is said to be only 0.0082 grain per cu ft.

Progressive Modernization

Engineering of December 15 describes modernization of the power plant of an Italian rayon mill in which the first step was the installation of a back-pressure turbine designed to use steam temporarily from old boilers at 228 lb and later to operate at 426 lb from new Tosi-Steinmueller boilers. This was accomplished by putting in only ten of the twenty stages of reaction blading. Now that the new boilers are in service the remaining ten stages have been added, together with an impulse wheel, and the capacity increased from 900 kw to 1400 kw with the same steam consumption as before, thus making the machine identical with a second unit since added.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request.

Air Preheaters

An attractive 20-page catalog has just been issued by The Air Preheater Corporation, Wellsville, N. Y., dealing with the construction and details of the Ljungström regenerative type of air preheater. These are fully illustrated and described, as well as numerous arrangements in connection with typical steam generating units. Dimensional tables are included and representative installations listed.

Blower Unit

Bulletin CO-3 issued by L. J. Wing Mfg. Co. describes its compound motorized blower as adapted especially to small stoker installations, particularly where space limitations prevail. Mounting diagrams are included and typical installations illustrated.

Chemical Feed

Bulletin No. 2233, issued by The Permutit Company, deals with its system of electro-chemical feed for apportioning chemicals in wet form at a constant or variable rate in connection with water conditioning. The device is fully described and illustrated.

Chemical Mixers and Feeders

Infilco products for chemical mixing, feeding and proportioning, for hydraulic measurement and control, and for conditioning water, processing liquids and trade wastes, all are illustrated and briefly described in a new condensed catalog issued by International Filter Co.

The catalog will be of special value to many industrial and processing plants, for it offers information in a compact form on all types of equipment used in such plants for liquid or waste treatment, chemical feeding and hydraulic control. Included are pH controlled lime feeders. Descriptions of equipment are supplemented by over forty illustrations.

Drainers

The Cochrane multiport drainer, which functions as a large capacity trap with the additional feature that flow of condensate is continuous rather than intermittent, is described in Bulletin No. 2925, just issued by the Cochrane Corporation. Its principal applications are to closed heaters, evaporators, continuous blow-off flush tanks, process machinery and similar equipment where large quantities of liquid must be continuously drained.

Dust Collectors

A new bulletin on Multiclone dust collectors and accessories has just been issued jointly by Research Corporation of New York and Western Precipitation Corporation of Los Angeles. Applications of the equipment in many types of industries are described and illustrated, and the law of cyclonic collection is discussed in non-technical terms. Tables covering the collection efficiency on particles of various sizes at various velocities in collectors ranging from 3 in. to 20 feet in diameter are included.

Electrical Measuring Instruments

A 66-page condensed catalog just issued by Leeds & Northrup Company lists its entire line of instruments for research and for routine testing in laboratory, plant and field. Standards, galvanometers and dynamometers, bridges, potentiometers, photometric apparatus, miscellaneous apparatus, primary elements, accessories, supplies, instrument parts are covered. Every standard L&N item is briefly described, and most of the principal ones are illustrated. For more complete descriptions and much supplementary information, the reader is referred to more detailed L&N publications. However, in choosing instruments and accessories for specific work in laboratory, plant or field, many will find this condensed catalog a useful guide.

Flame Detector

A new device which warns boiler operators of possible furnace explosion that may result from loss of ignition is described in bulletin No. 210 issued by Bailey Meter Company. This eight-page bulletin points out that the best assurance against an explosion hazard resulting from the loss of ignition is for operators to be fully acquainted with furnace conditions and for them to know that ignition is satisfactory. It describes and illustrates the construction and application of this device which affords protection against furnace explosion.

Instruments

"Boiler Room Instruments" is the title of a pamphlet issued by The Brown Instrument Company, which contains diagrams showing the location of various instruments essential to economical steam generation and intelligent boiler room operation. These instruments are briefly described and tables are included to assist in figuring fuel savings.

Insulation

A comprehensive 280-page loose-leaf insulation manual has been distributed by the Ehret Magnesia Manufacturing Company. It contains technical information on various insulations for both heat and cold, insulation accessories and fireproofing materials, pre-sealed insulated pipe, insulation recommendations and typical specifications, refractory cements, packings, building insulation, asbestos fibers and textiles, together with a large amount of useful data in the form of tables. The text is profusely illustrated with blueprint diagrams and sketches, as well as halftones.

Metering

"Industrial Metering" is the title of a 16-page fully-illustrated catalog lately brought out by the Pittsburgh Equitable Meter Company. Covered are numerous meter types for various applications, as well as special liquid meter registers, control and proportioning equipment. Gas meters and Nordstrom plug valves are also included.

Motors for Driving Auxiliaries

Induction-motor drives for power-station auxiliaries are illustrated and described in a booklet No. B-2218, issued by the Westinghouse Electric and Manufacturing Company. A helpful arrangement is adhered to in that a N.E.M.A. definition is given for each class of machine, such as open, drip-proof, splash-proof, self-ventilating, enclosed, and totally enclosed, fan-cooled. These definitions are followed by illustrations and descriptions of typical units under the particular class. Included also are discussions of structural features, bearings, stator windings and insulation, and form-wound coils for open-slot machines.

Pyrometers

Leeds & Northrup Company, 4934 Stenton Ave., Philadelphia, has brought out a new optical pyrometer employing the potentiometer principle but calibrated directly in degrees. It is described in catalog N-33D which, besides describing the instrument and its operation, also discusses the fundamentals of optical pyrometry in non-technical language.

Silent Chains

A 64-page illustrated catalog on silent chains and sprockets has been issued by the Whitney Chain & Mfg. Co. It is replete with tables arranged to be of assistance in calculating chain drives. Price lists are also included.

Steam Traps

Armstrong Machine Works has recently put out a new catalog and educational handbook on condensate drainage. Out of a total of 36 pages, 18 are devoted to material on rates of condensation, heat transfer, pipe sizes, piping layouts, main-

tenance, etc. Equipment covered by specific recommendations includes unit heaters, jacketed kettles, syphon-drained cylinders water heaters, pipe coils, steam mains and steam purifiers. The catalog pages list all products in the Armstrong line and give complete information on sizes, capacities, prices, etc. High spots are forged steel traps for 2400 lb pressure and compound traps with capacity for 300,000 lb of water per hour.

Superheaters

Combustion Engineering Company, Inc., has just issued a 24-page catalog on "Elesco" superheaters for stationary power plant service. Following a discussion of the economics of superheat, details of construction of both the ball-joint and welded types are given for the entire pressure range and applications to all representative types of boilers are shown. The arrangement of bypass damper control is explained and illustrated. There is also included material on the separately fired superheater for process work.

Synchronous Motors

Publication GEA-1191B, issued by General Electric Company, is a 52-page fully-illustrated booklet devoted to synchronous motors. Their general characteristics and adaptability are discussed at length, the construction details and operating characteristics of both high-speed and low-speed motors are included, and attention is given to special types. Also, considerable space is devoted to the applications of synchronous motors in industry and to synchronous motor-generators.

Valves and Fittings

A new 136-page fully-illustrated general catalog, No. 78, has just been published by The Lunkenheimer Company describing and listing its complete line of bronze, iron and steel valves, boiler mountings, lubricating devices and various fittings. Price lists and complete dimensional tables are included. The book is most attractively bound.

Water Analysis

Operating on the principle that the current which flows in a circuit containing a photoelectric cell is proportional to the illumination which the cell receives, and adapted to the determination of constituents producing either colorimetric or turbidimetric reactions, the "Nalco Phototester," described in a bulletin issued by National Aluminate Corporation, provides a convenient and time-saving means of making accurate water analyses.

Water Columns and Gages

Bulletin WG-1807 issued by Yarnall-Waring Company describes the "Yarway" floatless "Hi-Lo" alarm water columns with vertical or sesure-inclined water gages for various pressures up to 1500 lb per sq in. Included is the "Eye-Line" indicator for floor-level readings of boiler water levels, dimensional tables and price lists. By printing the bulletin in three colors an understanding of the operation of this equipment is facilitated.

Water Treatment

D. W. Haering & Company, Inc., announces the second printing of its booklet, "H-O-H Lighthouse Reprints," containing 20 pages of practical information regarding various water treatment problems. It is illustrated with charts, diagrams and pictures and discusses the causes of scale and corrosion and the quantities of corrective agents needed under varying conditions.

Worm Gears

The varied and numerous applications of worm gears in transmitting power from electric motors, water turbines, internal combustion engines, etc., to slow and moderate-speed machinery of all kinds are illustrated by appropriate photographs in a publication entitled "Worm Gears in Industry," which is being distributed by the De Laval Steam Turbine Co. The advantages of worm gear drive in the way of simplicity, smooth silent operation, uniform and positive flow of power, standardization of electric motor speeds, saving in floor space, safety to attendants and high efficiency are explained, specifications given, and standard forms of such gears described.

Unusual Set-Up of Small Mechanical-Drive Turbines

The E. B. Badger Company of Boston is being supplied by the General Electric Company with thirty small vertical turbines designed to drive, through the medium of double-reduction gears, centrifugal pumps which will handle molten salt employed in connection with the Houdry oil refining process.

These turbines are to be installed out of doors on towers 15 to 18 ft high and in climates where the temperature ranges at times from 40 deg below zero to 120 deg above, which made it necessary to design and supply with each of the turbine units an oil-temperature conditioning system so that the oil would not become overheated in summer nor frozen in winter. Furthermore, special care had to be exercised so that all passages in the units containing oil would automatically drain back to the oil reservoir in order to prevent the clogging of pipes during the shut-down periods that may be necessitated in cold weather.

These units, which are a modification of the standard mechanical-drive turbines and vary in capacity from 30 to 60 hp each operate over a speed range of 5500 to 2750 rpm and, through the reduction gears, drive the pumps normally at a speed of 1160 rpm. The versatility of mechanical-drive turbines results mainly from their ability to be operated throughout a wide range of speed which at all times must be under the control of some form of governor.

ADVERTISERS IN THIS ISSUE